RECORDING APPARATUS WITH OFFSET LINE HEADS

BACKGROUND OF THE INVENTION

The present invention relates to a recording apparatus provided with a plurality of print line heads for respective colors, for thereby performing color printing.

Conventionally, a color laser printer (CLBP) and a color ink jet printer (CIJP) of a serial printing method have been used as a color output apparatus for a personal computer (PC). Above all, the CIJP has been increasingly becoming popular in recent years due to its capability of printing a picture-quality image and its low cost. However, the CIJP is far inferior to the CLBP in terms of a printing speed.

Thus, a type that improved a printing speed with use of a line head is now becoming available, though few in number. Under the present situation, however, use of such a type is limited to a specific purpose, such as printing of business cards or printing of post cards. One of the reasons imposing this limitation is that it is difficult to manufacture a line head per se having a length equal to a width of A-4 size paper or the like.

In order to resolve these difficulties, there has been proposed an idea of forming a line head by disposing a plurality of individual heads in a direction (Y direction) perpendicular to a relative transportation direction (X direction) of a

recording medium for printing.

When a line head is formed by aligning a plurality of individual heads, it is needless to say that accuracy in placement of the individual heads is crucial. The individual heads are aligned with a positional accuracy of some micrometers in both X and Y directions, and an angle accuracy of 1/100 degree or less.

FIG. 8 is a characteristic view showing one example of a relationship between a nozzle position and a discharge quantity of ink droplets in an individual head.

As can be understood from this drawing, a discharge quantity is stable at a center of the individual head, but a discharge quantity of ink droplets decreases at both ends thereof due to irregularities during a fabrication sequence of the individual head, and the like. In short, it is general that the individual head has irregularities in terms of a discharge quality.

FIG. 9 is a characteristic view showing a discharge quantity of ink droplets from the line head in its entirety formed by aligning a plurality of individual heads having irregularities in terms of a discharge quality as described above.

As is shown in this drawing, the aforementioned characteristic of the individual head appears repetitively in a width cycle of the individual head.

FIG. 10 is a view used to explain an output result when a solid, uniform half-tone image is printed on a recording medium using the line head of FIG. 6 comprising the individual heads described above. As shown in FIG. 10, irregularities in terms of the discharge quantity appear as density-varying streaks.

Of the printing-related characteristics of the head, a discharge quantity of ink droplets has been described. It should be appreciated, however, that the head often shows a characteristic such that a discharge direction of ink droplets is also stable at the center and unstable at both ends of the individual head. Hence, at a joint portion of adjacent individual heads, dots formed on a recording medium from ink droplets are superimposed and an unwanted black streak may be produced, or dots are spaced apart and an unwanted white streak may be produced. Defects on an image, such as black streaks, white streaks, and density-varying streaks, are indicated by broken lines as shown in FIG. 11 for ease of explanation.

Next, FIG. 12 shows a schematic configuration when four line heads having a characteristic causing defects on an image as shown in FIG. 11 are aligned in the X direction for 4-color printing.

Referring to FIG. 12, a line head for yellow 1-Y, a line head for cyan 1-C, a line head for magenta 1-M, and a line head for black 1-K, each of which extends in the Y direction, are

placed in the X direction.

It goes without saying that a positional accuracy of the line heads for respective colors is crucial as is a positional accuracy of the individual heads in a single line head. Hence, for a conventional recording apparatus, an arrangement for performing highly accurate alignment with respect to the X direction, the Y direction and an angle, and a technique for correcting displacement are proposed, for example, in JP-A-62-290567/(1987) and JP-A-10-44474/(1998). This arrangement and technique forcedly correct positions of a plurality of line heads to an extent that the line heads can be deemed as being placed in equivalently the same positional relationship.

When color printing is performed by aligning a plurality of line heads for respective colors in the X direction as described above, characteristics of the line heads for respective colors are enhanced separately, which impairs image quality considerably.

FIG. 13 shows appearances of a printing result on a recording medium in this instance. It should be noted that defects on an image, such as black streaks, white streaks, and density-varying streaks, are actually enhanced and produced in the same position; however, a degree of defects is indicated by the number of broken lines because it is difficult to illustrate variations correctly in the drawing.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a recording apparatus provided with a plurality of print line heads for respective colors, for thereby performing color printing, and capable of ensuring a print quality without a need to increase an accuracy of components or add complicated processing.

In order to achieve the above and other objects, a recording apparatus of the invention includes: a first line head from which ink of a first color is discharged; a second line head from which ink of a second color is discharged; and relative movement structure for moving a recording medium relative to the first and second line heads, wherein the first line head is placed by being offset with respect to the second line head in a Y direction perpendicular to an X direction which is a relative transportation direction of the recording medium.

Consequently, even when the line heads for respective colors produce defects on an image, such as black streaks, white streaks, and density-varying streaks, these defects can be reduced by outputting respective colors to be superimposed. It is thus possible to ensure print quality without a need to improve an accuracy of components or add any complicated processing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an example of a schematic

configuration of a system of a recording apparatus according to one embodiment of the invention.

FIG. 2(a) is a view schematically showing a relative positional relationship between line heads for respective colors and a recording medium according to one embodiment of the invention.

FIG. 2(b) is a view schematically showing an alternative positional relationship between line heads.

FIGS. 3(a) to 3(d) are views schematically showing a relative positional relationship between line heads for respective colors and a recording medium with proceeding of a recording operation according to one embodiment of the invention.

FIG. 4 is a schematic view showing an enlarged portion of FIG. 2 to provide better understanding of an offset situation of the line heads in a Y direction according to one embodiment of the invention.

FIG. 5 is a schematic view showing appearances of a printing result on a recording medium when the line heads are offset according to one embodiment of the invention.

FIG. 6 is a schematic view showing a line head for use in a CIJP formed by providing a plurality of individual heads in the Y direction.

FIG. 7 is a schematic view showing an individual head in the line head of FIG. 6.

FIG. 8 is a characteristic view showing one example of a relationship between a nozzle position and a discharge quantity of ink droplets in an individual head.

FIG. 9 is a characteristic view showing a discharge quantity of ink droplets from an entire line head formed by aligning a plurality of individual heads.

FIG. 10 is a view used to explain an output result when a solid, uniform half-tone image is printed on a recording medium using the line head of FIG. 6.

FIG. 11 is a schematic view showing a printing result on a recording medium using the line head of FIG. 6.

FIG. 12 is a schematic view showing a configuration for 4-color printing by aligning four line heads of FIG. 6 in an X direction.

FIG. 13 is a schematic view showing a result of 4-color printing on a recording medium when four line heads of FIG. 6 are aligned in the X direction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the invention will now be described with reference to FIG. 1 through FIG. 5. Similar members are labeled with the same reference numerals in these drawings, and an explanation for these members will not be repeated.

Referring to FIG. 1, a recording apparatus connected to an external control apparatus 11, such as a PC, includes: an interface portion 12 to send/receive image data and control

commands of various kinds to/from the control apparatus 11; a memory 13 to store image data and control programs; a CPU 14 to control the recording apparatus in its entirety; a head control portion 15 to generate print data and a driving waveform for driving a piezoelectric head and supply the same to a head block 17 comprising a plurality of line heads 1; a motor control portion 16 to drive an LF motor 19 used to transport a recording medium 5; and an encoder sensor 18 to generate a pulse used as a control reference for the motor control portion 16 and the head control portion 15, by detecting a transported position of the recording medium 5.

FIG. 2(a) shows that a line head 1-Y for yellow, a line head 1-C for cyan, a line head 1-M for magenta, and a line head 1-K for black, each of which is formed to extend in a Y direction, are placed by being offset with a width OS in a direction (Y direction) perpendicular to a relative transportation direction (X direction) of the recording medium 5 for printing.

FIG. 2(b) shows an alternative arrangement in which first and third line heads 1′ and 1′′′ are offset in the Y direction relative to second line head 1′′, but are not offset relative to each other.

Referring to FIGS. 3(a) to 3(d), FIG. 3(a) shows a state where the recording medium 5 has reached a position at an end face of the line head 1-Y for yellow; FIG. 3(b) shows a state where the recording medium 5 has reached a position at an end

face of the line head 1-C for cyan; FIG. 3(c) shows a state where the recording medium 5 has reached a position at an end face of the line head 1-M for magenta; and FIG. 3(d) shows a state where the recording medium 5 has reached a position at an end face of the line head 1-K for black.

FIG. 6 is a schematic view showing a line head for use in a CIJP formed by providing a plurality of individual heads in the Y direction. As shown in this drawing, a line head 1 comprises a plurality of individual heads 2, herein eighteen line heads, arranged in the Y direction.

FIG. 7 is a schematic view of one individual head in the line head of FIG. 6. This individual head 2 includes two hundred nozzles 2a on a pitch of 133.87 μm, which are placed obliquely with respect to the Y direction at an angle of 71.565 degrees. This provides resolution in the X direction on a pitch of 127.00 μm (200 dpi) and resolution in the Y direction on a pitch of 42.33 μm (600 dpi) with three thousand six hundred nozzles in total. The nozzles 2a are located on a nozzle surface 2b of the head 2.

A recording operation by the recording apparatus configured as shown in the block diagram of FIG. 1 will now be described in outline with reference to the schematic views of FIG. 2(a) and FIG. 3.

Referring to FIG. 1, upon receipt of a command for a

recording operation from the control apparatus 11, such as an external PC, via the interface portion 12, the recording apparatus initially stores received image data into the memory 13, and performs necessary processing, such as image processing and sorting of the data according to head nozzle positions, while initializing the head control portion 15 and the motor control portion 16, all by virtue of the CPU 14.

When this initialization is completed by removing a capping used to prevent ink at the nozzle head surface 2b and/or in the nozzle 2a from drying, cleaning the nozzle head surface, setting a reference voltage of an amplifier supplying a head driving waveform, refreshing ink in the vicinity of nozzle ports through a forced discharge of ink droplets or meniscus vibrations, setting a reference original point and a control parameter of a recording medium transportation mechanism, moving the recording medium transportation mechanism to a printing start position, and the like, the LF motor 19 is driven by the motor control portion 16 to start transportation of the recording medium 5. In this instance, a relative positional relationship between the line heads 1 and the recording medium 5 is as shown in FIG. 2(a).

The recording medium 5 is transported forward, and when it reaches a printing start position for yellow shown in FIG. 3(a) the head control portion 15 supplies the line head for yellow 1-Y with recording data for yellow, whereupon printing

in yellow on the recording medium 5 is started. In this instance, the line head for cyan 1-C, the line head for magenta 1-M, and the line head for black 1-K are supplied with zero data (data that is not recorded).

The recording medium 5 is then transported further, and when it reaches a printing start position for cyan shown in FIG. 3(b) the head control portion 15 supplies the line head for cyan 1-C with recording data for cyan, whereupon printing in cyan on the recording medium 5 is also started. In this instance, the line head for magenta 1-M and the line head for black 1-K are supplied with zero data (data that is not recorded).

The recording medium 5 is then transported further, and when it reaches a printing start position for magenta shown in FIG. 3(c) the head control portion 15 supplies the line head for magenta 1-M with recording data for magenta, whereupon printing in magenta on the recording medium 5 is also started. In this instance, the line head for black 1-K is supplied with zero data (data that is need not recorded).

The recording medium 5 is then transported further, and when it reaches a printing start position for black shown in FIG. 3(d) the head control portion 15 supplies the line head for black 1-K with recording data for black, whereupon printing in black on the recording medium 5 is also started.

Transportation of the recording medium 5 by the motor control portion 16 and the recording operation by the head

control portion 15 are repeated thereafter, and recording on a single sheet of the recording medium 5 is completed in the same order when the recording started; that is, in order of yellow, cyan, magenta, and black.

When recording of a necessary number of sheets specified by the external control apparatus 11 is completed, the nozzle head surface is cleaned, the head is capped to prevent drying, the recording medium transportation mechanism is moved to a stand-by position, and the like, and the recording apparatus is thereby returned to an original stand-by state.

The above description described recording data in the X direction alone, and recording data in the Y direction will now be described with reference to FIG. 4. FIG. 4 is a view showing an enlarged portion of FIG. 2 to provide a better understanding of an offset situation of the line heads in the Y direction.

In a case where a character "·" is to be printed in a corner of the recording medium 5 using respective line heads, it is understood that a position of a nozzle used to record this "·" is shifted not only in the Y direction, but also in the X direction in the line heads for respective colors. Because each line head is offset in the Y direction, the nozzle that is used to record "·" is naturally shifted in the Y direction; moreover, it should be noted that, because individual heads 2 forming each line head are attached obliquely, the nozzle is

shifted also in the X direction. For this reason, a correction is necessary in processing by which image data read out from the memory 13 is supplied to the heads after the data is sorted according to positions of the head nozzles and an order of data transfer to the heads.

This correction does not complicate processing performed with use of a conventional technique; that is, a technique for correcting positions of a plurality of line heads to an extent that the line heads can be deemed as being placed in equivalently the same positional relationship. A mere difference is that whether plural line heads are aligned in the same positional relationship or are offset, and zero data that is not printed is appended to an offset image region.

In other words, according to this embodiment, by offsetting the line heads, it is possible to prevent deterioration in image quality by dispersing irregularities of a printing-related characteristic of the line heads color by color, and thereby making density-varying streaks, black streaks, and white streaks less noticeable, while preventing processing from becoming complicated.

FIG. 5 shows appearances of a printing result on a recording medium when the line heads are offset as has been described above.

Compared with FIG. 13 showing appearances of a printing result on a recording medium when line heads are not offset,

it is understood that the number of broken lines representing defects, such as black streaks, white streaks, density-varying streaks, is the same; however, they are dispersed uniformly. The defects, such as black streaks, white streaks, density-varying streaks, are enhanced more when they are concentrated, and thereby become more noticeable. This means, conversely, that the defects can be improved markedly when they are dispersed. In other words, when an image is printed on a recording medium by offsetting the line heads, the defects are dispersed as shown in FIG. 5, and image quality can be thereby improved significantly.

Generally, a white streak in an image is especially noticeable, and deteriorates image quality greatly. However, even when the line heads produce white streaks, in an image printed on a recording medium by offsetting the line heads, white streaks of a color are covered with another color, and the white steaks can be eliminated. Although differences in density of the color may remain, it remains as a fine line, and therefore, is not as noticeable as white streaks. Hence, by eliminating the white streaks, significant improving effects can be achieved.

In this embodiment, an explanation was given for a configuration in which the line heads for all the colors are offset. However, satisfactory effects for preventing deterioration in image quality can be expected by providing an

offset to the line heads for only particular colors having considerable visual influences, such as cyan, magenta, and black. In short, a desired effect can be achieved by providing an offset to at least a few of the line heads.

Further, in this embodiment, an explanation was given to a case where the width OS is given as an offset size between the line heads. However, it is preferable to set the offset size to be almost equal to a value found by dividing a print width of the individual heads forming the line head by the number of colors, because in this case defects, such as black streaks, white streaks, and density-varying streaks, can be dispersed uniformly. To be more specific, when 4-color printing is performed using individual heads having two hundred nozzles and resolution in the Y direction on a pitch of 42.33 μm (600 dpi), an offset is given as 42.33 μm × 200 / 4 = 2116.5 μm. This equals to fifty dots in a 600-dpi image, and the offset is naturally on a lattice of 600 dpi. Hence, an image will not be disturbed, and defects can be dispersed uniformly across a broadest region. Also, the recording apparatus was explained using an ink jet printer of a piezoelectric method as an example. It goes without saying that the same applies to an apparatus of any other method, for example, a thermal method.

In this specification, "set the offset size to be almost equal to a value found by dividing a print width of the individual

heads by the number of colors" means to set the offset size to a value in the vicinity of the value found by dividing the print width of the individual heads by the number of colors, and the value also should be an integral multiple of resolution of the nozzle in the Y direction.

Further, this embodiment explained a case of 4-color printing. However, the invention is applicable to multi-color printing (at least two colors), and is effective for printing in any other number of colors, for example, 3-, 6-, or 7-color printing.

In this embodiment, the recording apparatus performs recording by scanning recording medium 5; that is, by transporting the recording medium 5 in a main scanning direction, but the recording apparatus may perform recording by scanning the line heads 1 instead.

Further, in this embodiment, an explanation was given for a configuration in which the line head comprises a plurality of individual heads. However, the invention is effective when the line head comprises a single head. For example, in a case of a line head with a width of 216 mm, it is possible to achieve a satisfactory improving effect also in a visual manner by setting an offset size to a range from about 1 mm to about 6 mm.

Also, in this embodiment, an explanation was given for a case where the resolution in the X direction is on a pitch

of 127.00 μm (200 dpi) and the resolution in the Y direction is on a pitch of 42.33 μm (600 dpi). However, the invention is not limited to these resolutions.

As has been described, according to the invention, even when line heads for respective colors produce defects on an image, such as black streaks, white streaks, and density-varying streaks, these defects can be reduced by outputting the respective colors to be superimposed. It is thus possible to achieve advantages in that print quality can be ensured without a need to improve accuracy of components or add complicated processing.

CROSS REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of Japanese Patent Application No. 2002-359050 filed on December 11, 2002, the contents of which are incorporated herein by reference in its entirety.